ACCURACY OF CONE BEAM COMPUTED TOMOGRAPHY IN DETECTION OF WELL-DEFINED AND ILL-DEFINED CANCELLOUS BONE LESIONS

Bardal R,[1] Mostafavi M,[2] Tofangchiha M,[3] Akhlaghi P[4]

1. Assistant Professor, Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Qazvin University of Medical Sciences, Qazvin, Iran.
2. Assistant Professor, Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Urmia University of Medical Sciences, Urmia, Iran.
3. Associate Professor, Department of Oral and Maxillofacial Radiology, Dental Caries Prevention Research Center, Qazvin University of Medical Sciences, Qazvin, Iran.
4. General Dentist, Student Research Committee, Faculty of Dentistry, Qazvin University of Medical Sciences, Qazvin, Iran.

ABSTRACT

Aim: The objective of this study was to evaluate the accuracy of cone beam computed tomography (CBCT) in detection of cancellous bone lesions.

Materials & Method: Five dry mandibles were used. CBCT imaging was performed. Buccal and lingual plates of mandibles were separated and well-defined lesions with three different sizes under 4mm were produced by milling into the cancellous bone. After fixing the two parts together CBCT imaging was repeated. Cotton pellets moistened with 5% formic acid were put on the lesions and the two parts were fixed together. Presence or absence of lesions on images was recorded by 2 observers. Using SPSS 16, compatibility level and ROC analysis were determined for each observer.

Results: AUC also was low in three sizes of defects. The AUC before acid stages was significantly higher for both observers [0.827 (CI: 0.774-0.892) vs. 0.621 (CI: 0.336-0.607) for first observer and 0.662 (CI: 0.559-0.764) vs. 0.536 (CI: 0.329-0.0.544) for second observer]. There were no statistically significant differences in the accuracy of CBCT among different sizes of defects or among different sizes of defects in the three acid stages.

Conclusion: Detection of small ill-defined lesions not related to teeth within cancellous bone on CBCT images requires experience and great skill.

Key words: Cone-Beam Computed Tomography, Mandible, Cancellous Bone.

Introduction

Conventional radiographic techniques are important tools in the diagnosis and follow-up of intraosseous lesions of the jaws. However, the radiographs achieved do not have adequate accuracy due to their inherent limitations. The two-dimensional nature of these radiographic images prevents observation of the third dimensions of these lesions. The distortion produced in these images might also affect the diagnosis and determination of the size and location of the lesions. On the other hand, jaw lesions are surrounded by mandibular and maxillary bones. Therefore, superimposition of these anatomic structures on the lesions in two-dimensional images results in problems in the diagnosis, the severity of which is different based on lesion size, its location in the jaws and involvement of cortical plates.[1,2] Several studies have been carried out on the subject, based on some of which the lesions produced in cancellous bone cannot be diagnosed on periapical radiographs if erosion does not occur at the junction of cancellous and cortical bone.[3,4] However, some studies have not confirmed this.[5,6] Three-dimensional imaging techniques, such as CT and CBCT scans, have several advantages over conventional imaging techniques. Apart from the fact that they provide the opportunity to visualize the third dimension of the area involved, they eliminate the superimposition of anatomic structure and make it possible to diagnose and monitor lesions more accurately. Given the advantages of CBCT over CT, including availability, lower radiation dose and lower costs, at present CBCT techniques are more extensively used in maxillofacial imaging as a substitute for CT techniques in medicine.[7]

To date, various in vivo and ex vivo studies have evaluated the efficacy of CBCT technique in the diagnosis of intraosseous lesions and have shown higher accuracy of the technique in the diagnosis of these lesions. In some of these studies the lesions have been located in the cortical bone.[8,9] In some others, lesions within the cancellous bone have been evaluated. Except one study,[10] in all other studies on cancellous bone, in vivo[11-13] and in vitro[14-18] alike, the lesions evaluated have been of the periapical type and associated with teeth.

Considering the fact that no studies have been carried out on the diagnosis of well-defined and ill-defined lesions in the cancellous bone, which are not associated with teeth, the aim of the present study was to compare in vitro diagnostic agreement of well-defined and ill-defined lesions within cancellous bone.

Materials & Method

Considering In the present study five edentulous dry human mandibles were used. All the mandibles were sound and without any cracks.

Preparation of the control group

The mandibles were sectioned into three segments using a diamond disk with 30 mm diameter in a Kavo handpiece; one segment consisted of the canine-to-canine area and two others consisted of the posterior areas of the mandible. To simulate soft tissues, the osseous segments were separately placed in a water-filled box made of 3-mm-thick Plexiglass, measuring 3×10 cm; each sample was fixed inside the box parallel to the long axis of the box using a piece of tape stick. Promax 3D (Planmeca, Helsinki, Finland) machine was used to capture CBCT images. All samples were fixed on the machine in a manner to direct the laser beam through the center of the long axis of the box.

Preparation of well-defined lesions

Each osseous segment was sectioned into two buccal and lingual segments using the T 118A Bosch jig saw blade in a manner to leave more cancellous bone on the buccal segment. Lesions were produced artificially within the osseous bone using a round bur; #V bur was used to produce round lesions measuring 1.6 mm in diameter and oval lesions measuring approximately 1.6×3 mm and #XI bur was used to randomly create lesions measuring approximately 4 mm in diameter in the anterior and posterior regions. The lesion sizes were approximate due to great porosity of the dry bone, especially in the posterior region, and brittleness of the bony trabeculae. Of course, the approximate sizes of the lesions had no negative effect on the diagnosis due to great differences in lesion sizes. Subsequent to creation of the lesions, the lingual plate was fixed adjacent to the buccal plate and CBCT images were captured similar to the method used for the control group.

Preparation of Ill-Defined Lesions

An acid was needed to produce ill-defined lesions, which would not change the sizes of the lesions. Therefore, 5% formic acid was selected. A cotton pellet impregnated with 5% formic acid was placed within the lesions and the lingual plate was again fixed adjacent to the buccal plate. CBCT imaging was repeated 1 and 2 weeks after application of formic acid.

Visualization of CBCT images

The images were visualized by two oral and maxillofacial radiologists with one-year experience, who worked as assistant professors at the university and received similar instructions in relation to the diagnosis of the lesions. The images visualized in a room with the lights dimmed with no time limitation. The CT images submitted to the observers on a CD and visualized on a 19-inch LED monitor (LG FLATRON E1940sv Seoul, Korea), with a resolution of 1440×900. All the three observers were oral and maxillofacial radiologist,

Interpretation of Images

The observers reported the presence or absence of lesions with different sizes on intra-oral images based on a 5-point confidence rating scale as follows: 1, definitive presence of a lesion; 2, possible presence of a lesion; 3, no definitive decision; 4, possible absence of a lesion; 5, definitive absence of a lesion.

The CBCT images were visualized using the Romexis software at a resolution of 0.16. The images were divided in two quadrants at MPR (Multiplanar reconstruction). Posterior sections were divided into quadrants of superior to and inferior to the canal; in the anterior regions, first, the curve or the convexity of the bone was placed facing downward and the right half was assigned to quadrant 1 and the left half was assigned to quadrant 2.

In order to diagnose the lesions, in the first stage the image in the axial view was placed on the middle section and the sagittal axis of the image was placed in the direction of the sagittal axis of the software. In the next stage, the image in the sagittal view was evaluated by moving the mouse from the buccal bone toward the lingual bone; if the possible lesion was observed, the junction of the sagittal and coronal planes were placed at the center of the lesion and the lesion was evaluated on the coronal view in the next stage. If the lesion was visualized on the coronal view, its presence was confirmed. The process was repeated for each quadrant. In anterior views, adjustment of the sagittal and coronal planes of the bone on the axial view was separately carried out for each quadrant.

Statistical Analysis of Data

Data were analyzed with SPSS 16 statistical software.

The accuracy [(true positive + true negative) ÷ total observations] of both observers was measured and compared with the AUC (Area Under Roc Curve) and the related confidence intervals; in this context, the following accuracy levels were defined: I. <0.65: low accuracy; II.0.65-0.75: moderate accuracy; III. 0.75-0.85: good accuracy; IV.0.85-1: excellent accuracy.

Results

Total accuracy without considering acid stages and size of defects for both observers was low (AUC<0.65) (Figure 1).

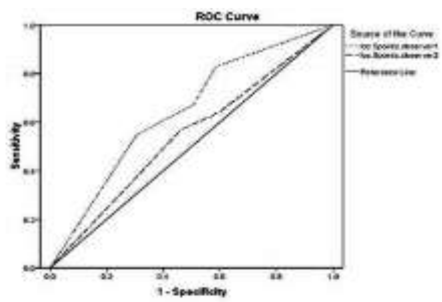

Figure 1: Receiver operating characteristic curves separately for observers.

According to table 1, AUC also was low in three sizes of defects.

	Size 1	Size 2	Size 3
Observer 1	0.543	0.660	0.613
Observer 2	0.638	0.492	0.632

Table 1: AUC of two observers with regard to size

The AUC before acid stages was significantly higher for both observers [0.827 (CI: 0.774-0.892) vs. 0.621 (CI: 0.336-0.607) for first observer and 0.662 (CI: 0.559-0.764) vs. 0.536 (CI: 0.329-0.0.544) for second observer, Table 2].

	AUC before acid (CI)	AUC 1 week after acid (CI)	AUC 2 weeks after acid (CI)
Observer 1	0.827 (0.774,0.892)	0.621 (0.336,0.607)	0.504 (0.329,0.678)
Observer 2	0.662 (0.559,0.764)	0.536 (0.329,0.714)	0.374 (0.184,0.555)

Table 2: Areas under curve (AUC) of two observers with regard to acid stages

There were no statistically significant differences in the accuracy of CBCT among different sizes of defects or among different sizes of defects in the three acid stages. [Table 3]

	AUC Before acid(CI)	AUC 1 week after acid(CI)	AUC 2 weeks after acid(CI)
Size 1	0.575 (0.470,0.681)	0.547 (0.399,0.694)	0.411 (0.253,0.569)
Size 2	0.621 (0.514,0.727)	0.588 (0.210,0.966)	0.389 (0.203,0.543)
Size 3	0.621 (0.516,0.726)	0.659 (0.480,0.839)	0.430 (0.190,0.589)

Table 3: AUC irrespective of observers and with regard to size

Discussion

Early diagnosis of intraosseous lesions in many diseases with periodontal and endodontic origins has a great role in the course of such conditions. In addition, early diagnosis of inflammatory diseases, such as osteomyelitis and malignant metastasis, which are more prevalent in advancing age, can contribute to the treatment of these diseases and increase the life expectancy of the elderly.

Dry mandibles used in this study to imitate such conditions to create not related to teeth, well and ill-defined early intaosseous lesions.

A study by Patel *et al*. showed a high accuracy rate (ROC, AUC=1) for the diagnosis of periapical lesions on CBCT images.[20]

Liang *et al*. reported the positive and negative predictive values and accuracy for CBCT in diagnosing periapical lesions were all 1, compared with 1, 0.64 and 0.79 for PA diagnosis.[18] Sogur *et al*., too, reported a high accuracy rate ($0.74 \leq AUC \leq 0.93$) for the diagnosis of chemically produced periapical lesions.[17]
A systematic review of Diagnostic Accuracy of CBCT and Conventional Radiography on Apical Periodontitis, showed high accuracy values (AUC=0.96) for CBCT imaging, 0.73 and 0.72 for conventional periapical radiography, and digital periapical radiography respectively.[21]

According to table 1, AUC was low in three sizes of defects and showed that the AUC before acid stages was significantly higher; unfortunately, created lesion sizes were not determined after acid stages; however according to table 3 the size of these defects had no effect on the accuracy of the diagnosis. Furthermore, it can be concluded that the lesion outlines had resulted in the differences observed.

It can be concluded that diagnosis of small lesions which are not associated with teeth within the cancellous bone on CBCT images is not recommended.

Shulze *et al*. reported good diagnostic accuracy of CBCT images in patients with clinical signs of osteomyelitis.[22] A study by Hendrikx *et al*. showed a high success rate of CBCT for the evaluation of bone invasion by SCC and concluded that CBCT can be considered a new diagnostic tool in screening for oral SCC in order to predict invasion or absence of invasion of the mandible. Fullmer *et al*. provided CBCT images from patients suspected of having osteomyelitis and described osteomyelitis views on CBCT images. Differential diagnosis was made between these lesions and malignancies. A study by Momin *et al*. showed a higher rate of accuracy ($Az \geq 0.918$) for CBCT in determining the involvement of the mandible in the carcinoma of mandibular gingiva. The difference between the studies which have shown a high rate of CBCT accuracy in the evaluation of malignant lesions and the present study is the fact that all the selected patients had clinical signs, and the evaluated lesions were not completely circumscribed within cancellous bone. Therefore, differential diagnosis of these lesion with bone marrow spaces was not difficult, finally the lesions in vivo might have other initial radiographic signs such as periosteal reactions, sclerotic bone in the periphery etc.[23]

Therefore, it is not possible to conclude that the results achieved through in vitro studies are thoroughly applicable to in vivo conditions due to differences between in vivo and in vitro conditions.[24]

Conclusion

In conclusion diagnosis of small lesions within the cancellous bone on CBCT images in the elderly for inflammatory and malignant lesions in early stages in cases in which there are no clinical signs are not recommended.

References

1. Bender IB. Factors influencing the radiographic appearance of bony lesions. J Endod. 1997;23(1):5-14.
2. Grondahl HG, Huumonen S. Radiographic manifestations of periapical inflammatory lesions. Endod Topics. 2004;8(1):55–67.
3. Bender IB, Seltzer S. Roentgenographic and direct observation of experimental lesions in bone: II. 1961. J Endod. 2003;29(11):707-712.
4. Schwartz SF, Foster JK Jr. Roentgenographic interpretation of experimentally produced bony lesions.I. Oral Surg Oral Med Oral Pathol. 1971;32(4):606-612.
5. Lee S-J, Messer HH. Radiographic appearance of artificially prepared periapical lesions confined to cancellous bone. Int Endod J. 1986;19(2):64-72.
6. Shoha RR, Dowson J, Richards AG. Radiographic interpretation of experimentally produced bony lesions. Oral Surg Oral Med Oral Pathol. 1974;38(2):294-303.
7. Ludlow JB, Davies-Ludlow LE, Brooks SL, Howerton WB. Dosimetry of 3 CBCT devices for oral and maxillofacial radiology: CB Mercuray, NewTom

3G and i-CAT. Dentomaxillofac Radiol. 2006;35(4):219-226.
8. Gaia BF, Sales MA, Perrella A, Fenyo-Pereira M, Cavalcanti MG. Comparison between cone-beam and multislice computed tomography for identification of simulated bone lesions. Braz Oral Res. 2011;25(4):362-368.
9. Marques AP, Perrella A, Arita ES, Pereira MF, Cavalcanti Mde G. Assessment of simulated mandibular condyle bone lesions by cone beam computed tomography. Braz Oral Res. 2010;24(4):467-474.
10. Bardal R, Jahanihashemi H, Mostafavi M, Kalhor E, Tofangchiha M, Dehghani M. Accuracy of Cone Beam Computed Tomography, Photostimulable Phosphor Plate Digital Radiography and Conventional Radiography for Detection of Artificial Cancellous Bone Defects. J Dent (Tehran). 2015;12(11):797-806.
11. Lofthag-Hansen S, Huumonen S, Gröndahl K, Gröndahl HG. Limited cone-beam CT and intraoral radiography for the diagnosis of periapical pathology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;103(1):114-119.
12. Estrela C, Bueno MR, Leles CR, Azevedo B, Azevedo JR. Accuracy of cone beam computed tomography and panoramic and periapical radiography for detection of apical periodontitis. J Endod. 2008;34(3):273-279.
13. Patel S, Wilson R, Dawood A, Mannocci F. The detection of periapical pathosis using periapical radiography and cone beam computed tomography - part 1: pre-operative status. Int Endod J. 2012;45(8):702-710.
14. Kamburoğlu K, Kiliç C, Ozen T, Horasan S. Accuracy of chemically created periapical lesion measurements using limited cone beam computed tomography. Dentomaxillofac Radiol. 2010;39(2):95-99.
15. Ozen T, Kamburoğlu K, Cebeci AR, Yüksel SP, Paksoy CS. Interpretation of chemically created periapical lesions using 2 different dental cone-beam computerized tomography units, an intraoral digital sensor, and conventional film. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107(3):426-432.
16. Sogur E, Baksi BG, Gröndahl HG, Lomcali G, Sen BH. Detectability of chemically induced periapical lesions by limited cone beam computed tomography, intra-oral digital and conventional film radiography. Dentomaxillofac Radiol. 2009;38(7):458-464.
17. Soğur E, Gröndahl HG, Baksı BG, Mert A. Does a combination of two radiographs increase accuracy in detecting acid-induced periapical lesions and does it approach the accuracy of cone-beam computed tomography scanning? J Endod. 2012;38(2):131-136.
18. Liang YH, Jiang L, Gao XJ, Shemesh H, Wesselink PR, Wu MK. Detection and measurement of artificial periapical lesions by cone-beam computed tomography. Int Endod J. 2014;47(4):332-338.
19. Noujeim M, Prihoda T, Langlais R, Nummikoski P. Evaluation of high-resolution cone beam computed tomography in the detection of simulated interradicular bone lesions. Dentomaxillofac Radiol. 2009;38(3):156-162.
20. Patel S, Dawood A, Mannocci F, Wilson R, Pitt Ford T. Detection of periapical bone defects in human jaws using cone beam computed tomography and intraoral radiography. Int Endod J. 2009;42(6):507-515.
21. Leonardi Dutra K, Haas L, Porporatti AL, Flores-Mir C, Nascimento Santos J, Mezzomo LA, *et al*. Diagnostic accuracy of cone-beam computed tomography and conventional radiography on apical periodontitis: a systematic review and meta-analysis. J Endod. 2016;42(3):356-364.
22. Schulze D, Blessmann M, Pohlenz P, Wagner KW, Heiland M. Diagnostic criteria for the detection of mandibular osteomyelitis using cone-beam computed tomography. Dentomaxillofac Radiol. 2006;35(4):232-235.
23. Hendrikx AW, Maal T, Dieleman F, Van Cann EM, Merkx MA. Cone-beam CT in the assessment of mandibular invasion by oral squamous cell carcinoma: results of the preliminary study. Int J Oral Maxillofac Surg. 2010;39(5):436-439.
24. Fullmer JM, Scarfe WC, Kushner GM, Alpert B, Farman AG. Cone beam computed tomographic findings in refractory chronic suppurative osteomyelitis of the mandible. Br J Oral Maxillofac Surg. 2007;45(5):364-371.

Corresponding Author

Dr.Maryam Tofangchiha
Associate Professor,
Department of Oral and Maxillofacial Radiology,
Dental Caries Prevention Research Center,
Qazvin University of Medical Sciences,
Bahonar Blvd., Qazvin, Iran
Email Id: - mt_tofangchiha@yahoo.com